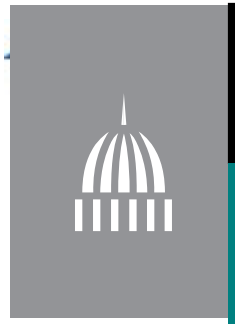


NATIONAL CONFERENCE of STATE LEGISLATURES

The Forum for America's Ideas

Transportation Technology and Policy Symposium

Infrastructure Requirements of Advanced-Technology Vehicles

Marianne Mintz

May 10, 2001

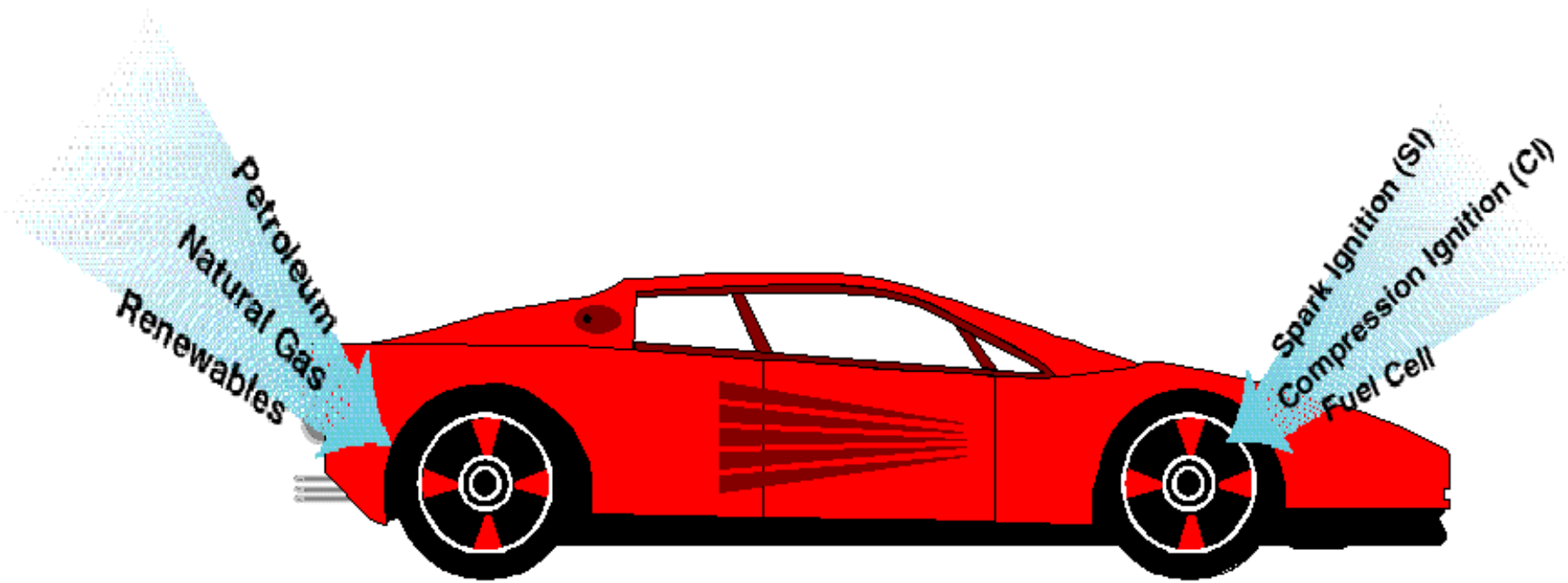
Infrastructure Includes

- Right-of-way
- Vehicle/component manufacturing, assembly, and distribution
- Vehicle sales and service
- Fuel production and distribution

Each of Which May Be Examined in Terms of

- Cost
- Energy use
- Criteria pollutant emissions
- Greenhouse gas emissions
- Safety

ANL Has Estimated Fuel Infrastructure Costs for Several Combinations of Propulsion Systems and Resources



Boundaries of This Presentation

- Mid to long term (2020 and 2030)
- Light-duty vehicles
- Capital costs of fuel production and distribution infrastructure (excluding exploration)
- Technically feasible propulsion systems with potential for substantial improvement over conventional internal combustion engine fuel efficiency (hybrids and fuel cells)
- Unconventional motor fuels (ethanol, methanol, and hydrogen)

Advanced-Technology Fuel/Propulsion Combinations Considered

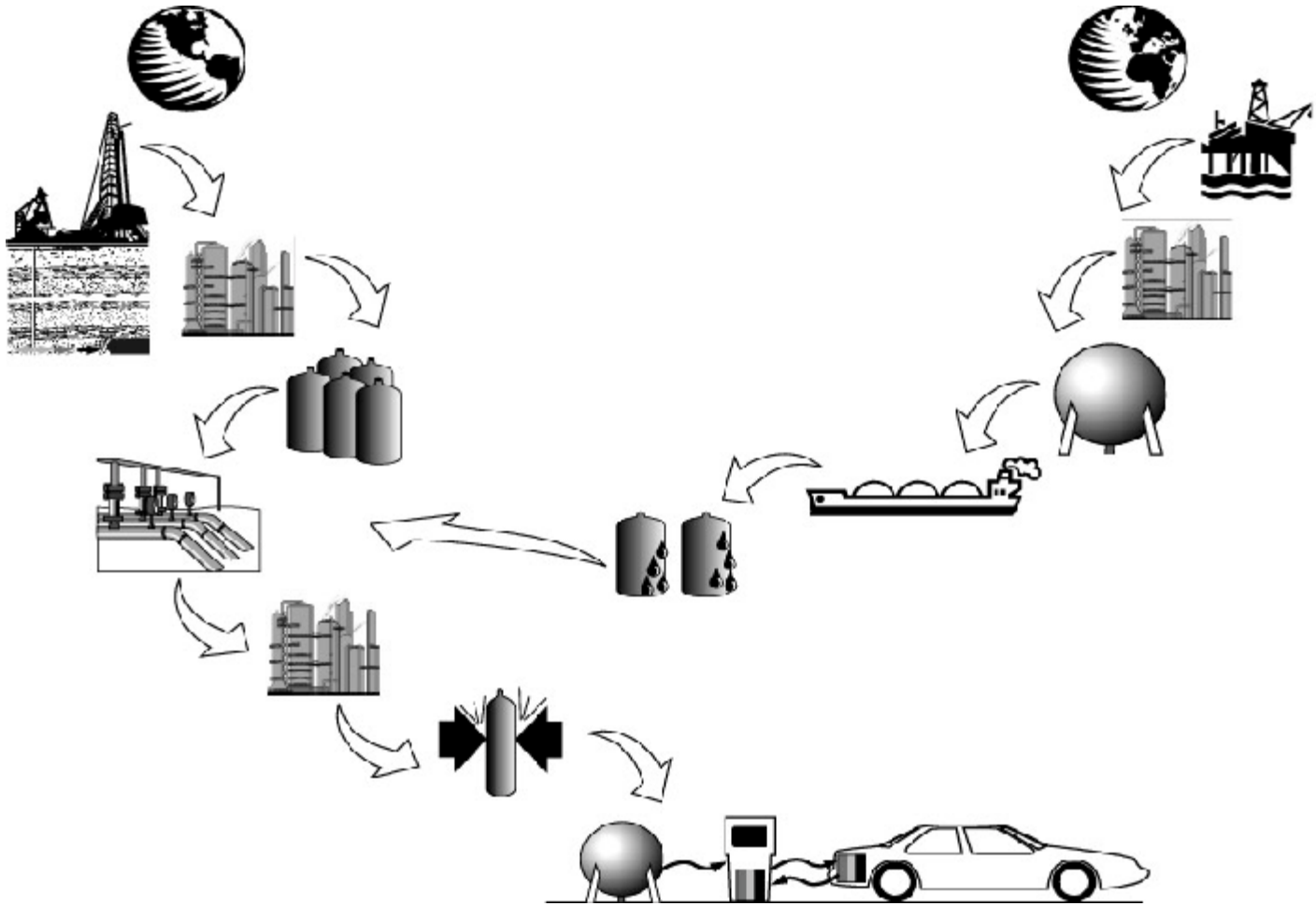
Fuel Cell (FC) Vehicles

- Gaseous hydrogen
- Methanol reforming
- Ethanol reforming
- Gasoline reforming
- Diesel reforming

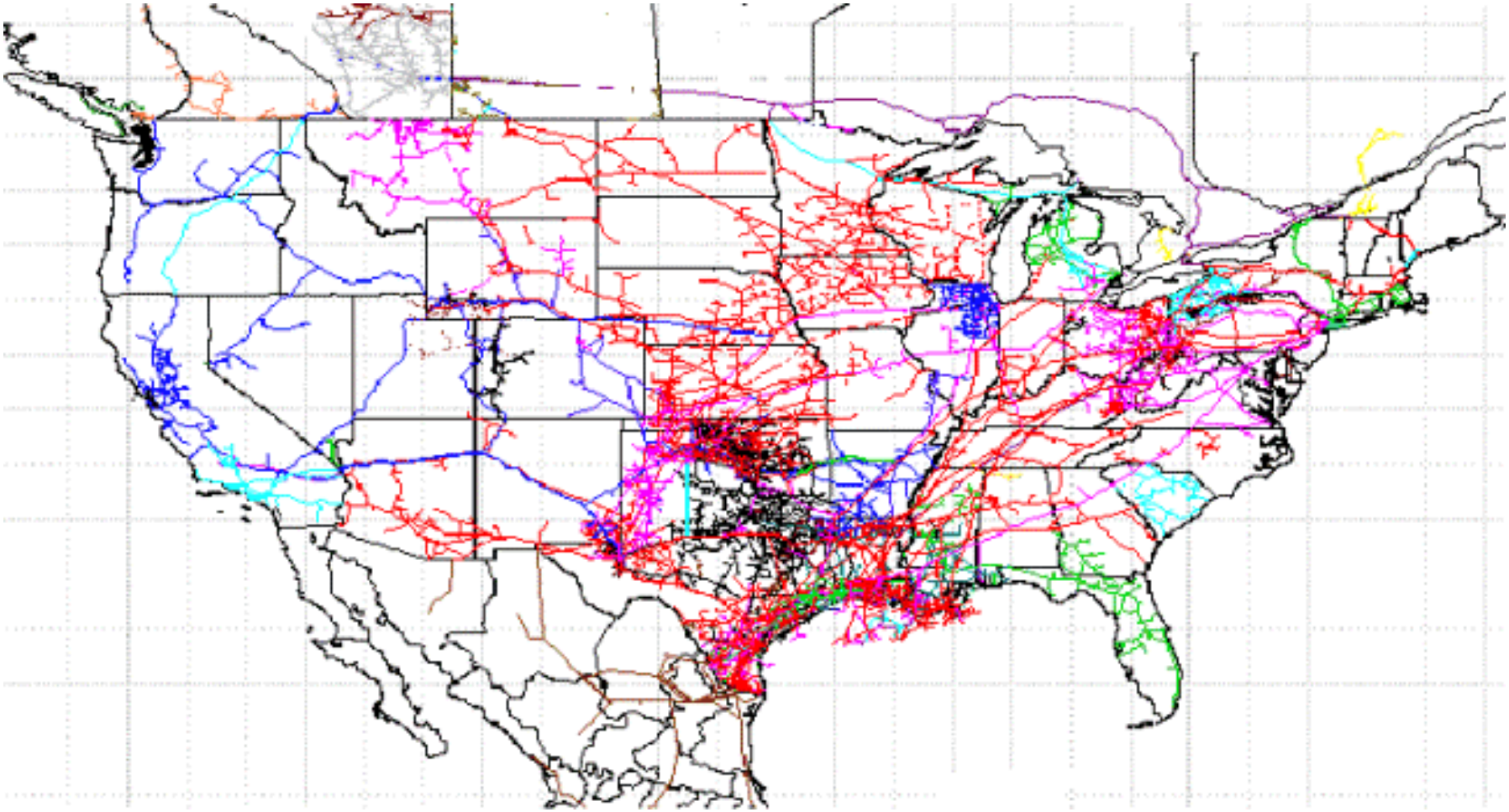
Hybrid Vehicles

- Gaseous hydrogen
- Methanol FC
- Ethanol FC
- Gasoline FC
- Diesel FC

Natural Gas-Based Fuels Could Take Several Paths from "Well" to "Tank"



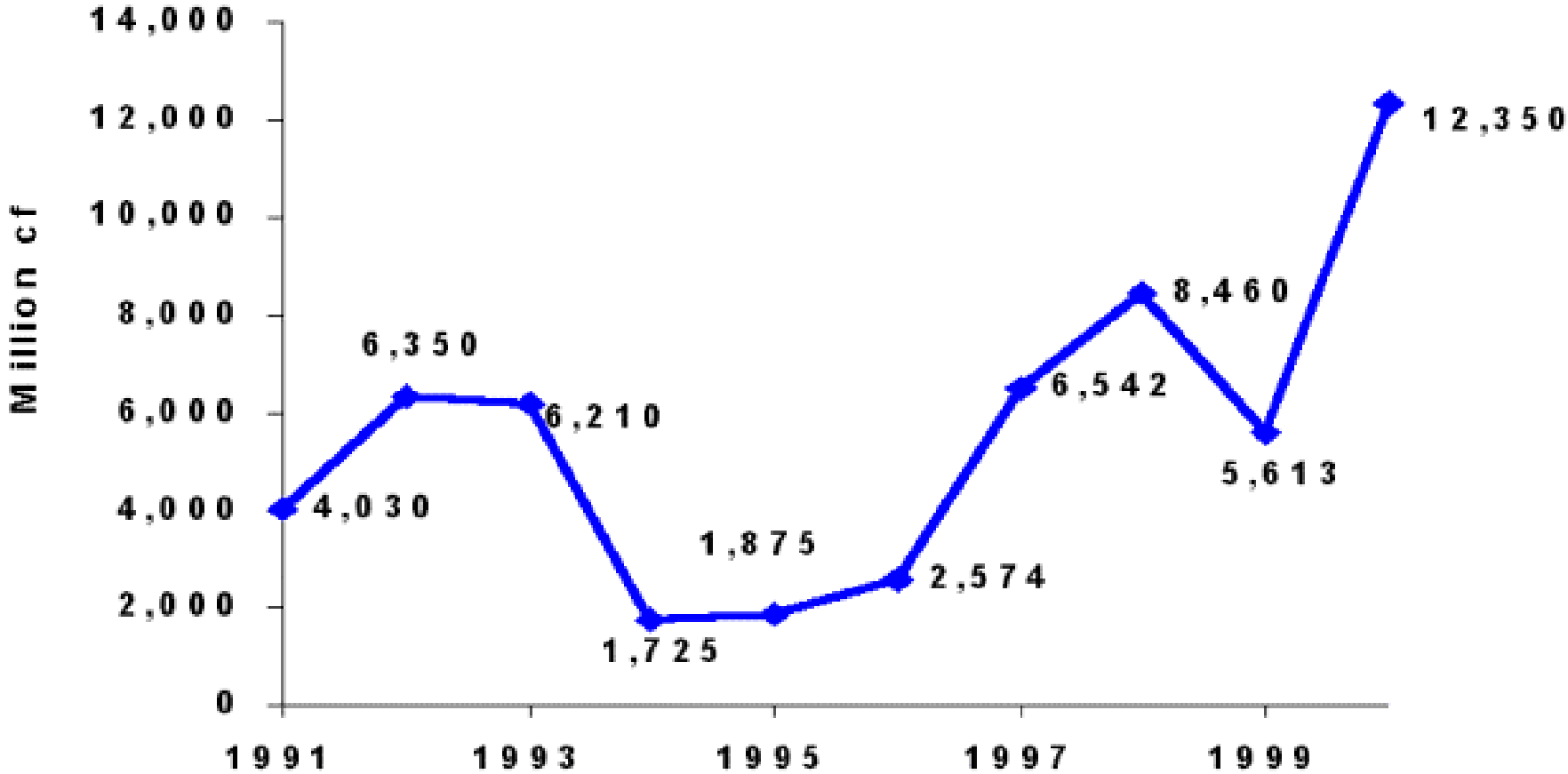
Natural Gas Has an Extensive In-Place Transmission Infrastructure



And a Track Record of Continually Expanding Transmission Capacity

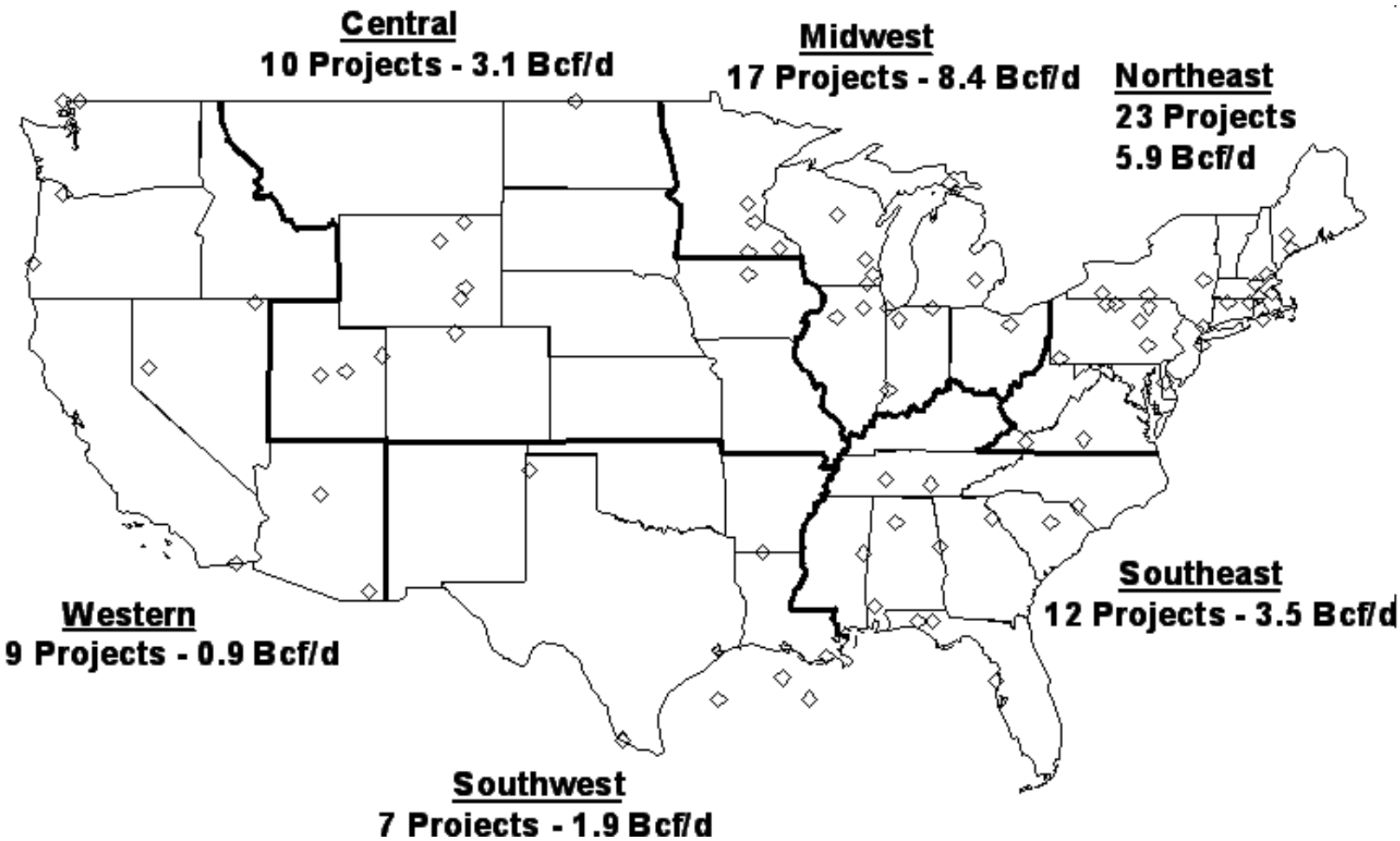
- New pipelines
- Additional compression
- Looping
- A combination of each

Since the Mid-1990s Transmission Capacity Has Grown > 4 Bcf/d Each Yr



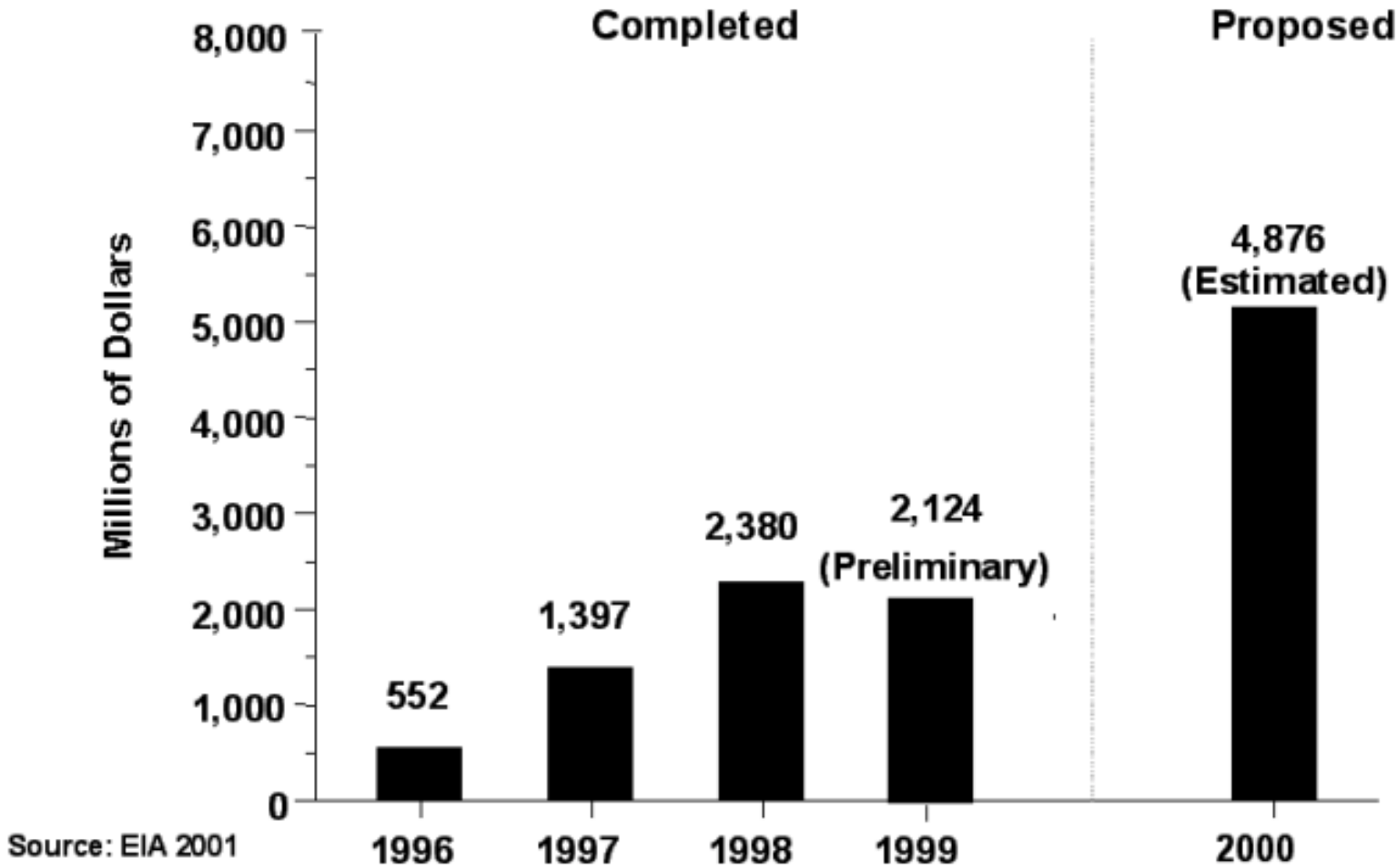
Source: EIA 2001

Yearly Capacity Additions Could Double to 8 Bcf/d Over the Next 3 Yr



Source: EIA 2001

According to EIA, Nearly $5B Was Spent on Pipeline Expansion in 2000

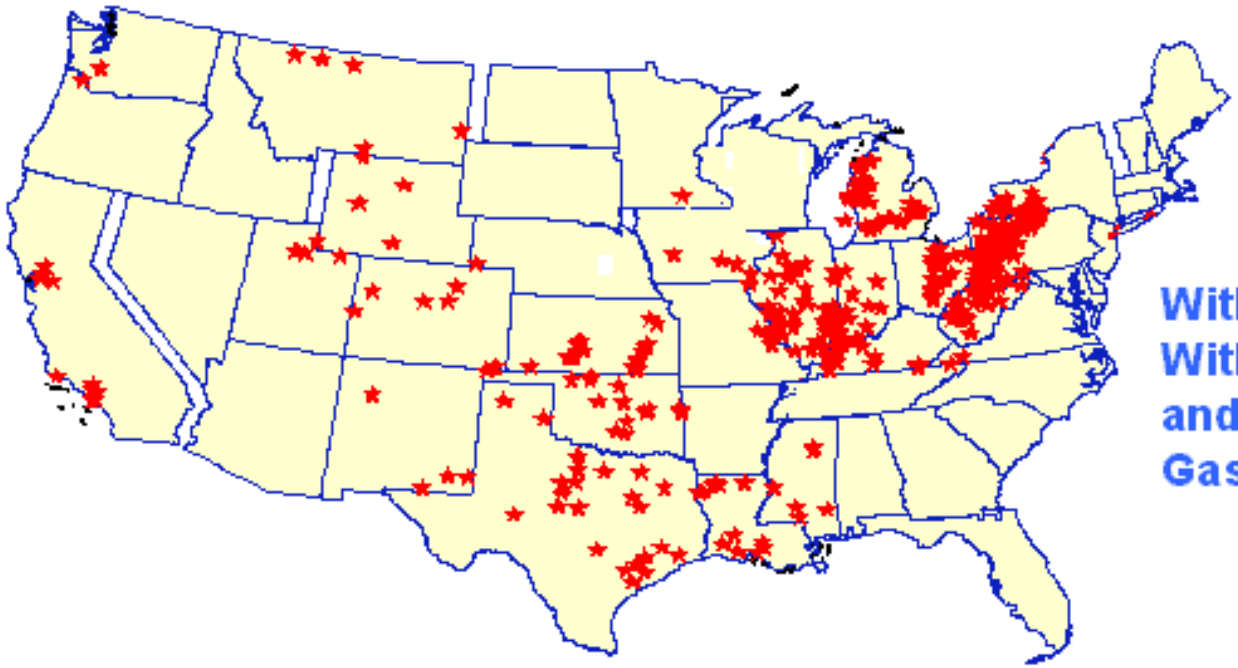


Expansion Reflects Shifts in the Structure of the Industry and Its Resource Base

- Increased production in deep-water Gulf of Mexico and in Western and offshore Eastern Canada
- Reduced production in mature provinces
- Shippers seeking greater access to alternate sources of supply
- Producers seeking greater access to nontraditional markets (market integration)
- Increased use for power generation with resulting shifts in seasonal demand patterns

The Natural Gas Pathway Also Includes Extensive Storage Facilities

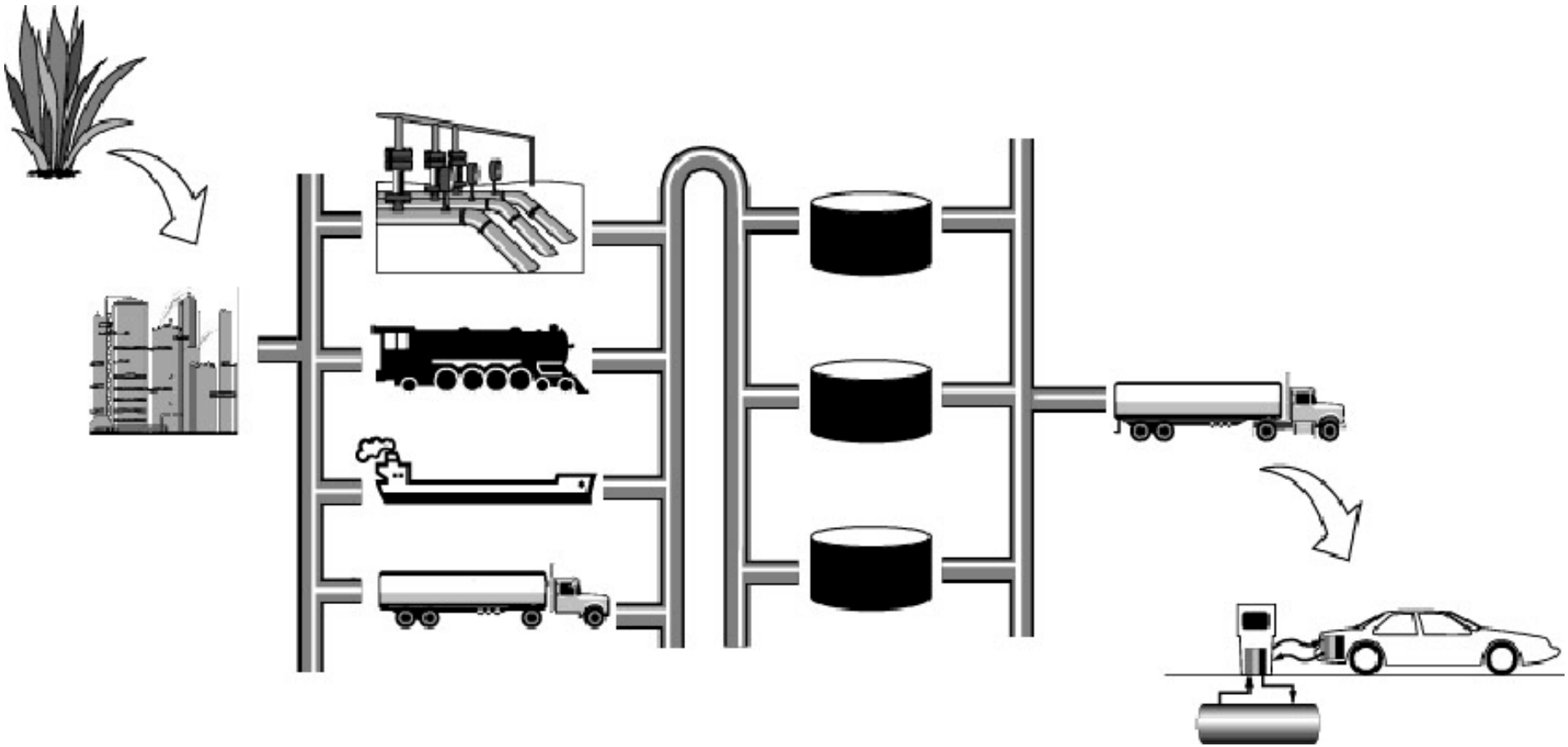
At the end of 1998 there were 410 underground natural gas storage sites in the United States



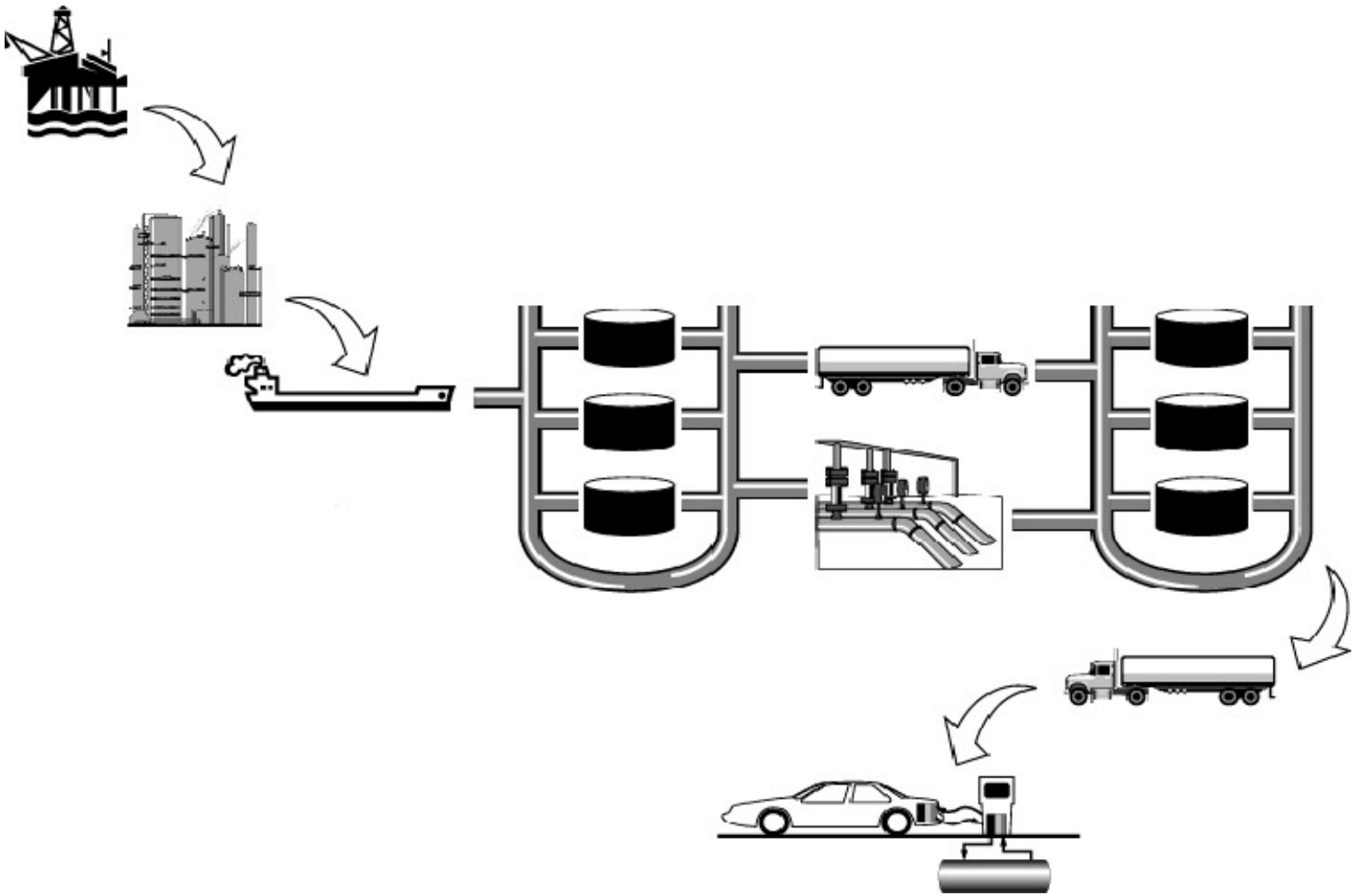
With 76 Bcf per day of Withdrawal Capability and 3,933 Bcf of Working Gas Capacity

www.eia.doe.gov
Energy Information Administration

Today Ethanol Moves Mainly by Truck and Rail; Pipelines Require Higher Volumes



Methanol Also Moves Mainly by Truck from Ports to Terminals & Service Stations



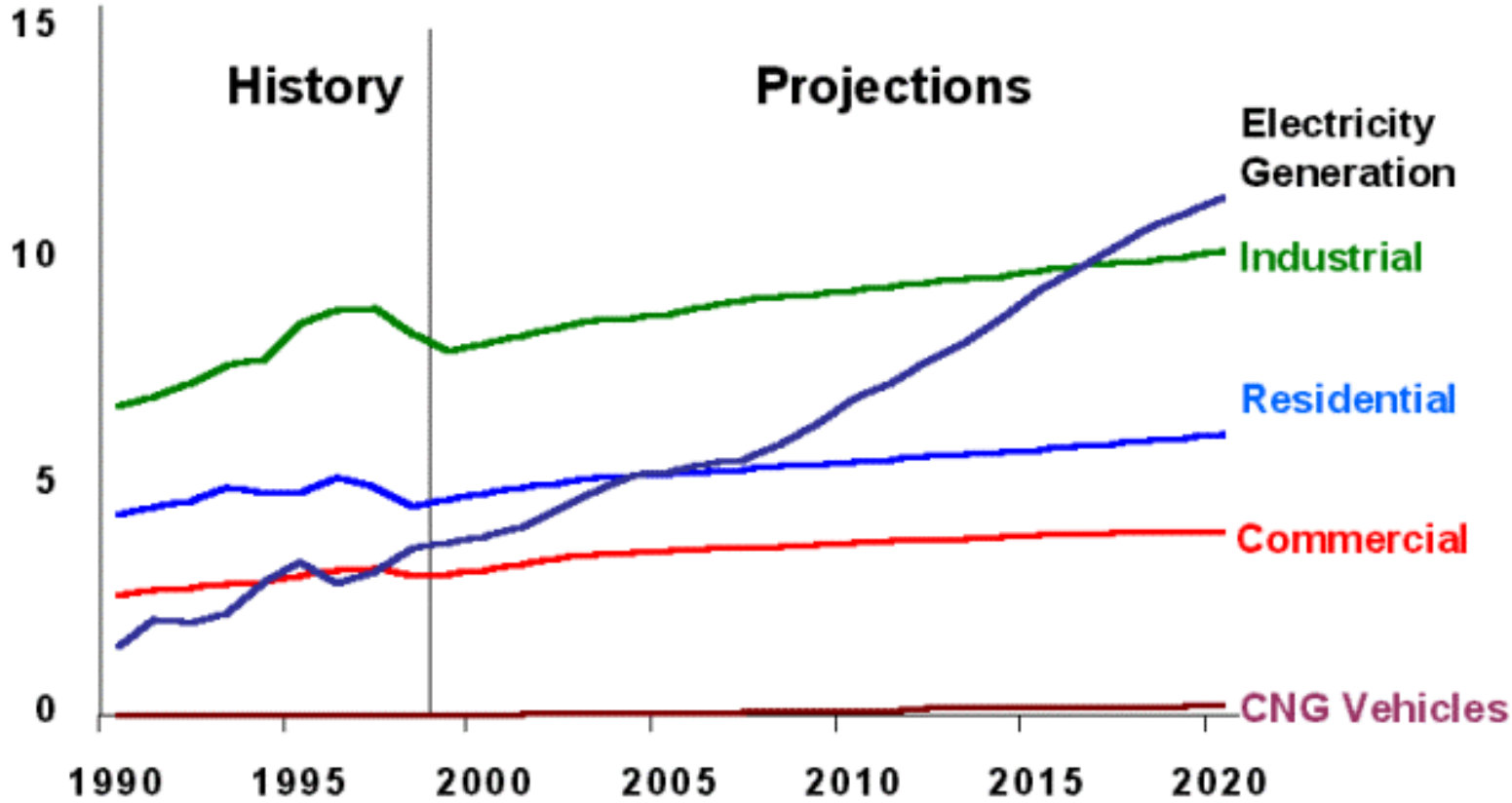
Outlook for Non-Petroleum Motor Fuels Is Mixed

- No obvious impediment to increasing capacity of existing infrastructure
  - Emissions regulations
  - Capital availability
- Competing demands could limit availability and/or bid up prices
- Development of new infrastructure, on a large scale, could be costly

Key Features of EIA's Current Natural Gas Forecast

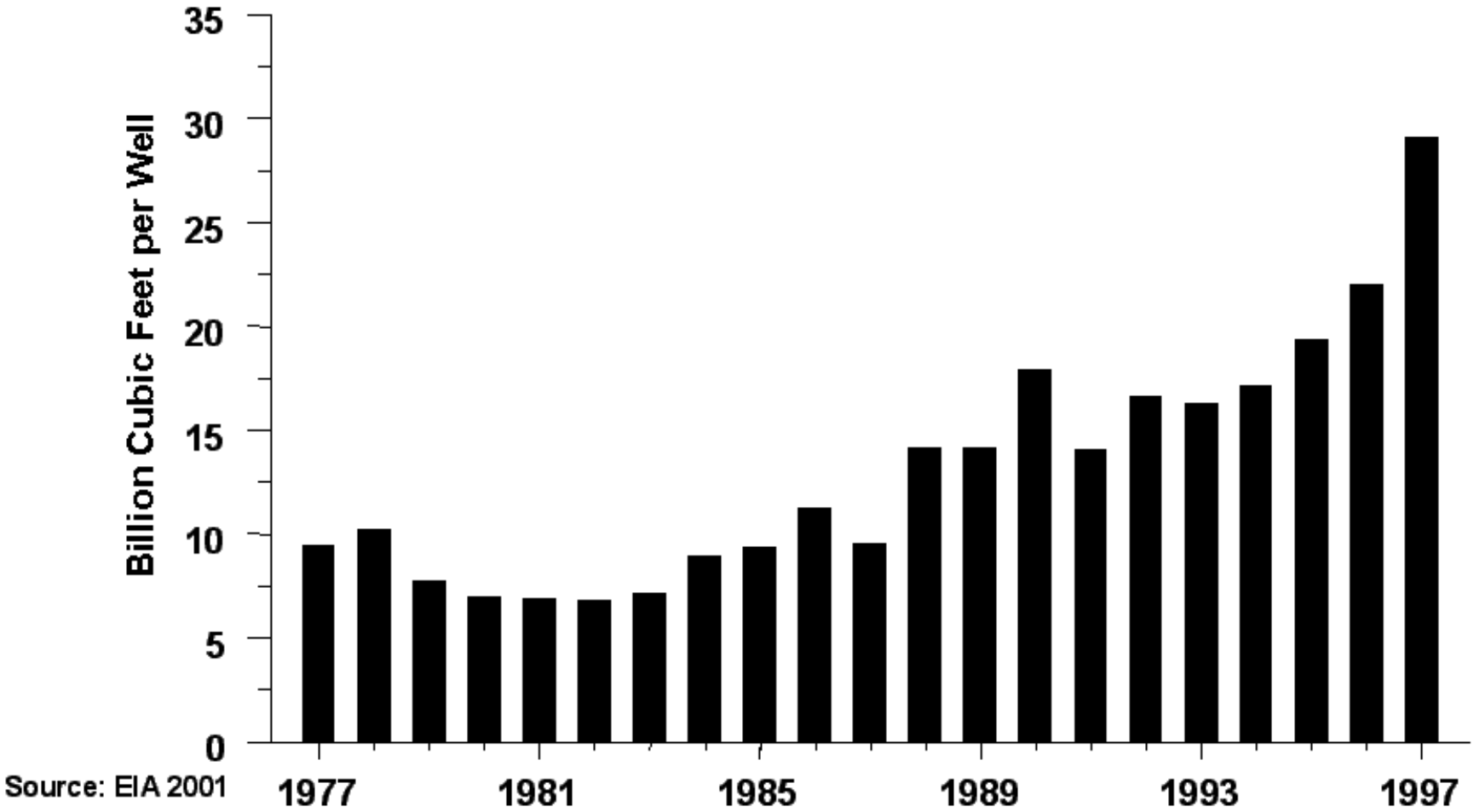
- Demand grows to 32 tcf in 2015, 34 tcf in 2020
- Prices drop after 2001, then increase slowly to about $3.10 (1999 $/mcf) in 2020
- Imports increase to about 5 tcf in 2020
- Steady prices and lower drilling costs increase reserve additions and production
- Technology improvements limit E&P cost increases

Most Growth in Natural Gas Demand Comes from Power Generation. Is This Likely?



Source: EIA 2001

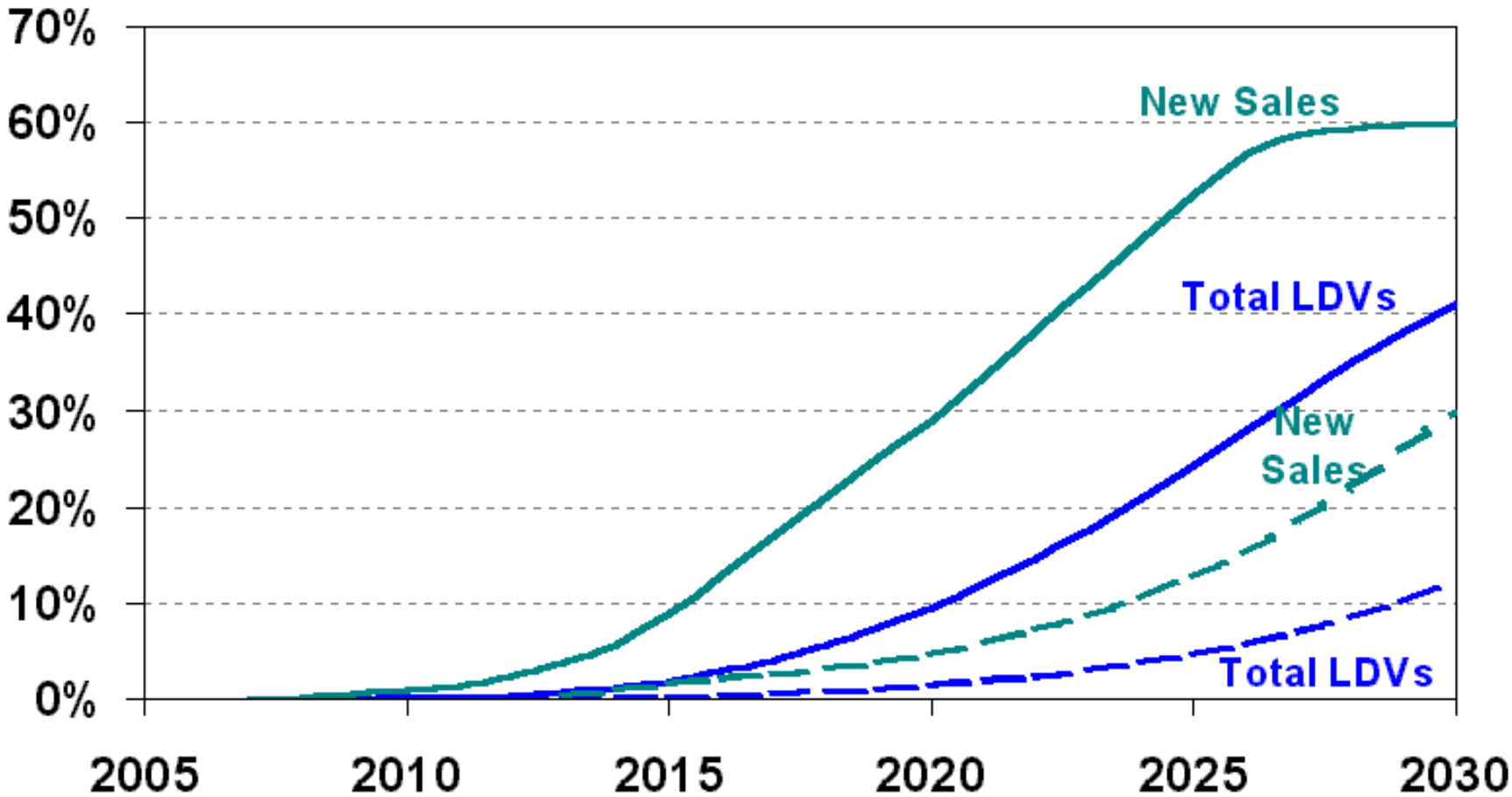
Discoveries Per Exploratory Gas Well Have Been Growing Since the Mid-1980s



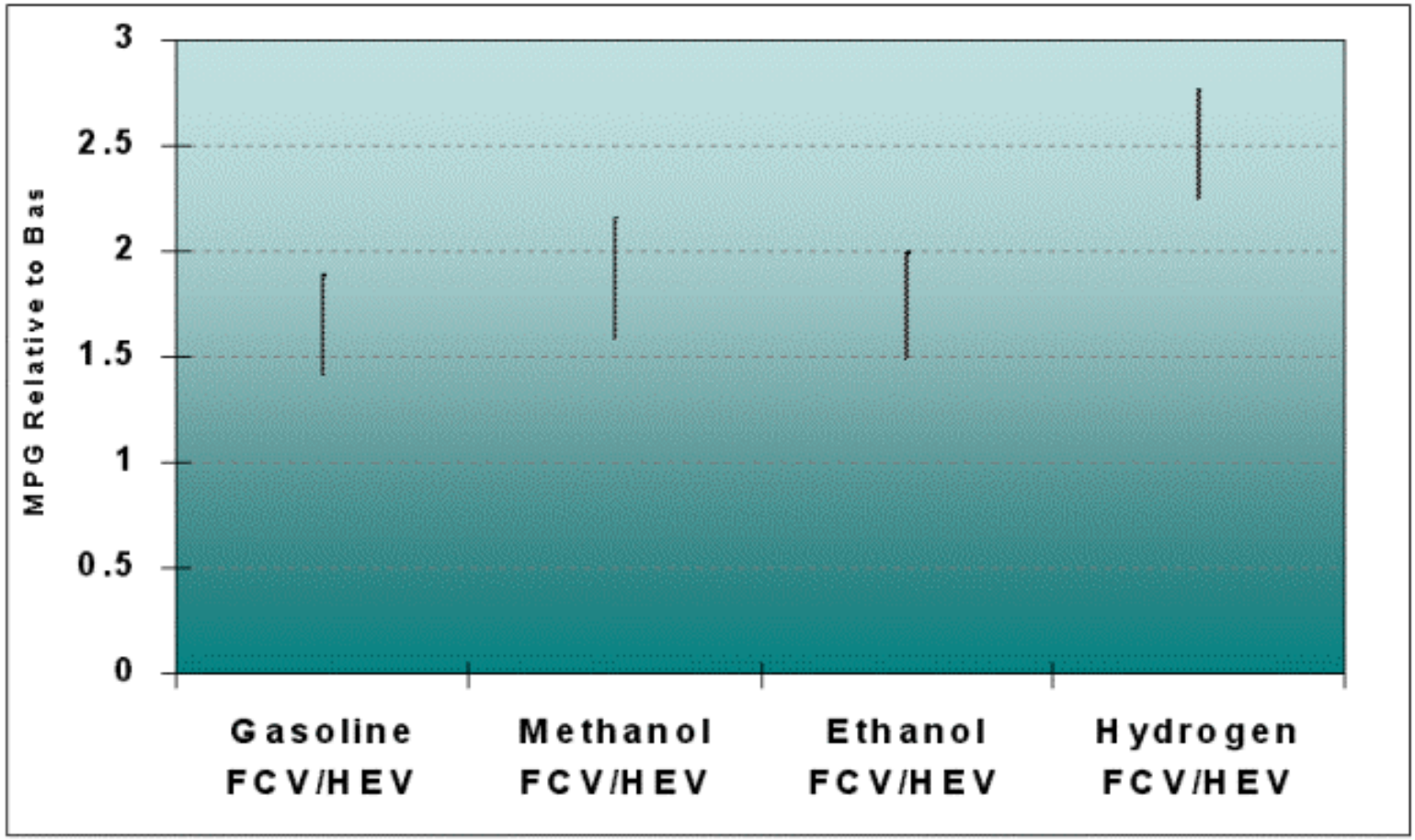
Source: EIA 2001

Will there be sufficient North American natural gas production to supply a large-scale shift to natural-gas-based motor fuels?

Demand for Non-Petroleum Motor Fuel Was Examined for Two Market Penetration Cases

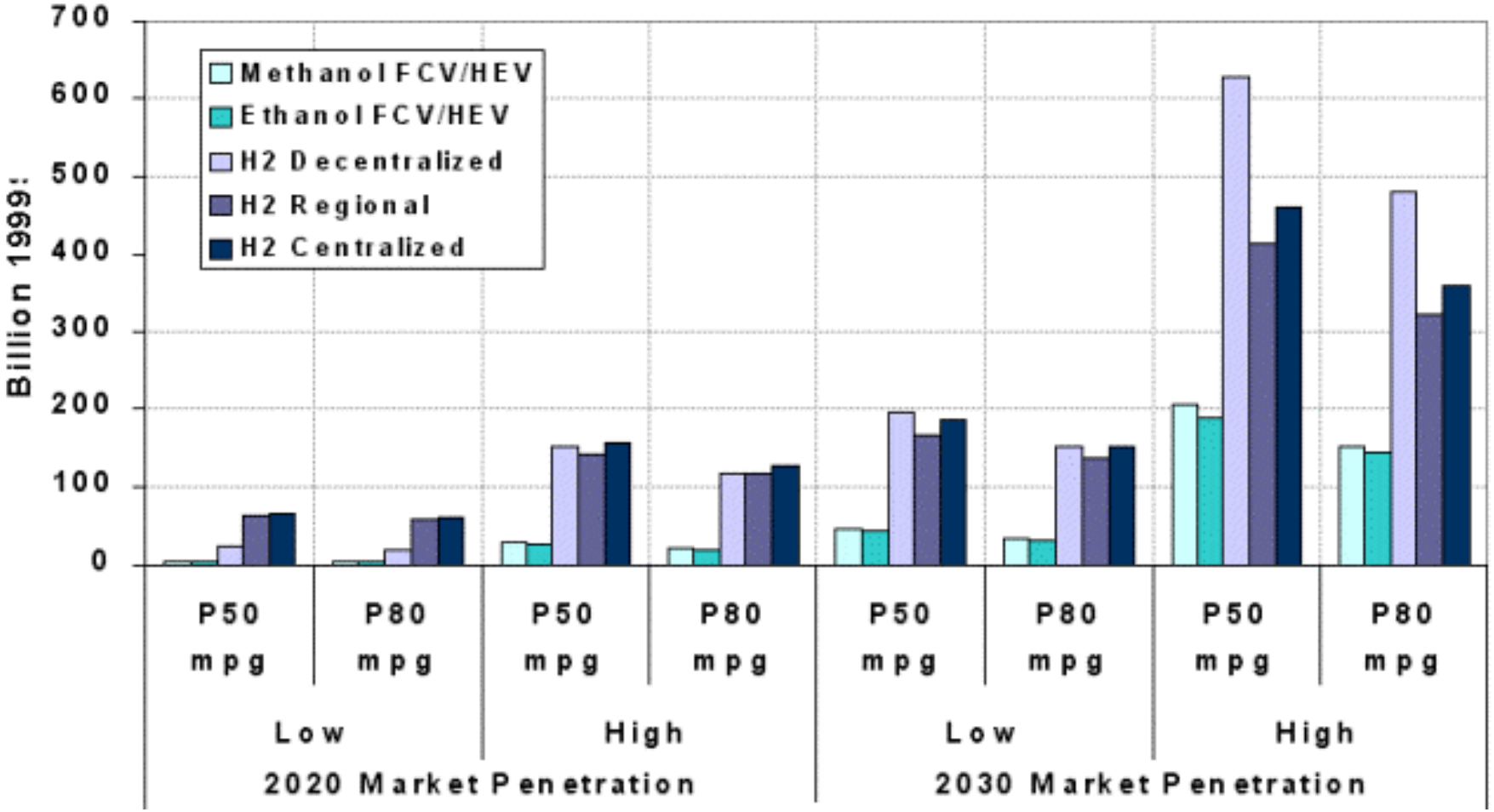


MPG Could Be 1.4-2.75 Times Better Than the Base Vehicle, Depending on Option and Success of Technology Development



Source: GAPC et al. 2001

Despite Efficiency Advantages, H2 Options Are Very Costly; Alcohols Look Promising



Fuel Infrastructure Costs Depend on Unit Costs and Structure of Pathway Itself

- Unit cost reduction
  modular, standard design station reformers

- Alternative pathways
  - Thermochemical H2 (solar or nuclear)
  - Gas-to-liquids (not likely for FCVs)
  - Compressed natural gas hybrids

From What We've Learned We Think We Can Now Ask the Right Questions

- Should natural gas be used as a motor fuel?
- If so, what is the best pathway?
- If not, what will be the successor to petroleum motor fuels?